FireFly

UCI Samueli School of Engineering

2025 WINTER DESIGN

ANALYSIS

Fire Detection Analysis

Justification

- **OpenCV** library built for efficiency and performance of vision processing tasks (perfect for our use case that prioritizes latency) with a large ecosystem
- **OpenCV** is capable of upscaling if we wanted to improve our color filtering algorithm to a deep learning algorithm
- **OpenCV** is very compatible with the hardwares and softwares we are using for our prejject (raspberry pi, raspberry pi camera module, python). OpenCV is light weight making it run easily on a raspberry pi. OpenCV also has python wrappers making it easy to integrate with other python-based libraries for deep learning

Results

- Captures frame and processes color filtering algorithm between .01 and .05 seconds
- Accurately only boxes contours with a red color

Figure 04: Color detection capabilities of the OpenCV library

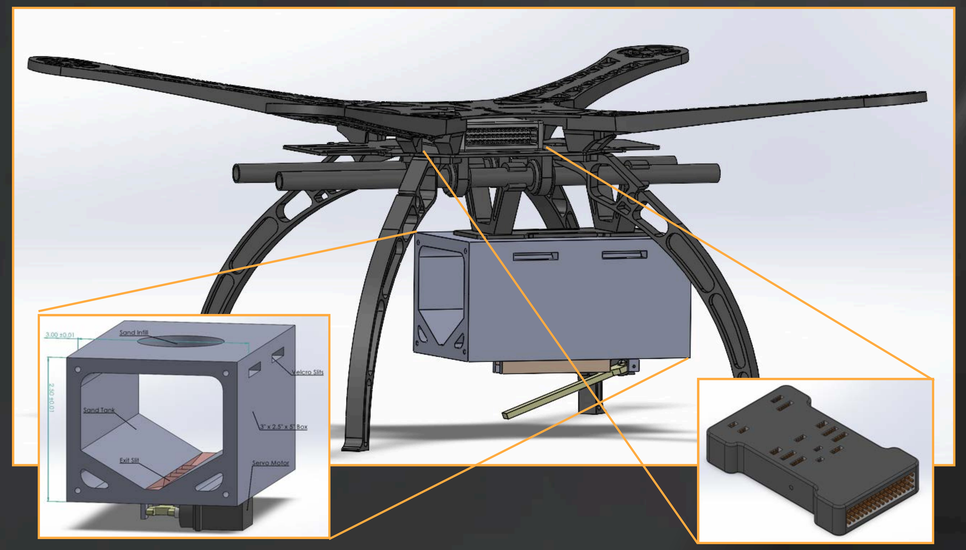
IMPROVEMENTS

- **Implement a deep learning algorithm to detect fires in more diverse situations such as smoky conditions.**
- **Train model to not only detect fires but people and vehicles that are in the vicinity**
- **Implement infrared cameras for additional redundancies to reduce false positives**
- **Implement countermeasures against leftover buildup on hatch that would prevent motor from fully closing**
- **Implement rigid supports to prevent payload from skewing center of gravity**

ENVIRONMENTAL

- **Early Detection and Monitoring:** Drone can detect wildfires in their initial stages especially in remote areas. This enable rapid response which prevent small fires turning into large scale disaster
- **Enhanced Firefighting efforts:** During active wildfire, drones provide real time data on fire behavior, hotspot, and spread pattern. This information is then used for organizing firefighting efforts, minimizing risk to ground personnel, and assisting in evacuation planning.
- **Post-Fire Assessment:** After containment, drone assist in mapping affected areas, evaluating extent of damage, and possible environmental impacts. This data then can be used for rehabilitation efforts and future fire prevention planning.

DESIGN



SUMMARY

Wildfires cause widespread devastation due to rapid spread and limited early detection. Our project aims to combat this issue using autonomous drones equipped with AI-driven fire detection and rapid intervention systems. Utilizing thermal, smoke, and LiDAR sensors, the drone can identify fires early, alert nearby stations, and deploy fire retardant to contain them. A small-scale prototype will validate our detection and intervention methods before full-scale implementation.

TEAM

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HONORS

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References

- [1] OpenCV. "Image Processing in OpenCV." OpenCV Documentation, OpenCV, https://docs.opencv.org
- [2] WFCA (Western Fire Chiefs Association). "Drones for Wildfire Surveillance." WFCA, https://wfca.com
- [3] UC Davis. "New Drone Research Advances Wildfire Monitoring." UC Davis, 6 Sept. 2023, https://www.ucdavis.edu

SUBSYSTEM

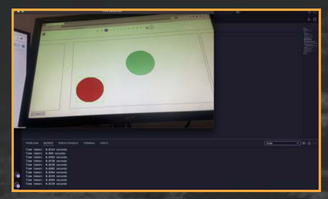
Figure 01: Exploded view of the Pix Hawk flight controller

Flight Controller

- Uses the PixHawk
- This is essentially the brains of the FireFly that connects the fire detection system to the physical movements of the drone
- Maintains the stability for drone flight and provide an interface for the sensors to function

Flight Controller Code Logic

Fire Detection



- Uses a Raspberry Pi Model B+, Raspberry Pi Camera Module 2, and openCV library to detect fires in real time
- Red detection will be the main sensor due to price constraints but ideally redundancy should be in place to confirm the presence of fire

Figure 02: Shows the detection of red when multiple colors are present

Intervention System

- For our purposes we use a single servo motor latch system to slowly dispense sand in a streamline fashion
- The servo's purpose is to dynamically release the sand as re-correction occurs in the drone
- The mechanism is intended to be attached via Velcro and has an internal slope to minimize congestion

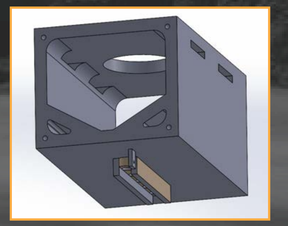


Figure 03: CAD of the stand alone intervention payload

Structure

- The sourced ST450 (seen on left) the main attributes valued were weight capacity, compatibility, and flight time
- The drone boast a 3lb carrying capacity, PixHawk compatibility, and 18 minutes of flight time